Supporting Information:

Wafer-Scale Nanopatterning and Translation into High Performance Piezoelectric Nanowires

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Nanowires of Various Sizes and Shapes

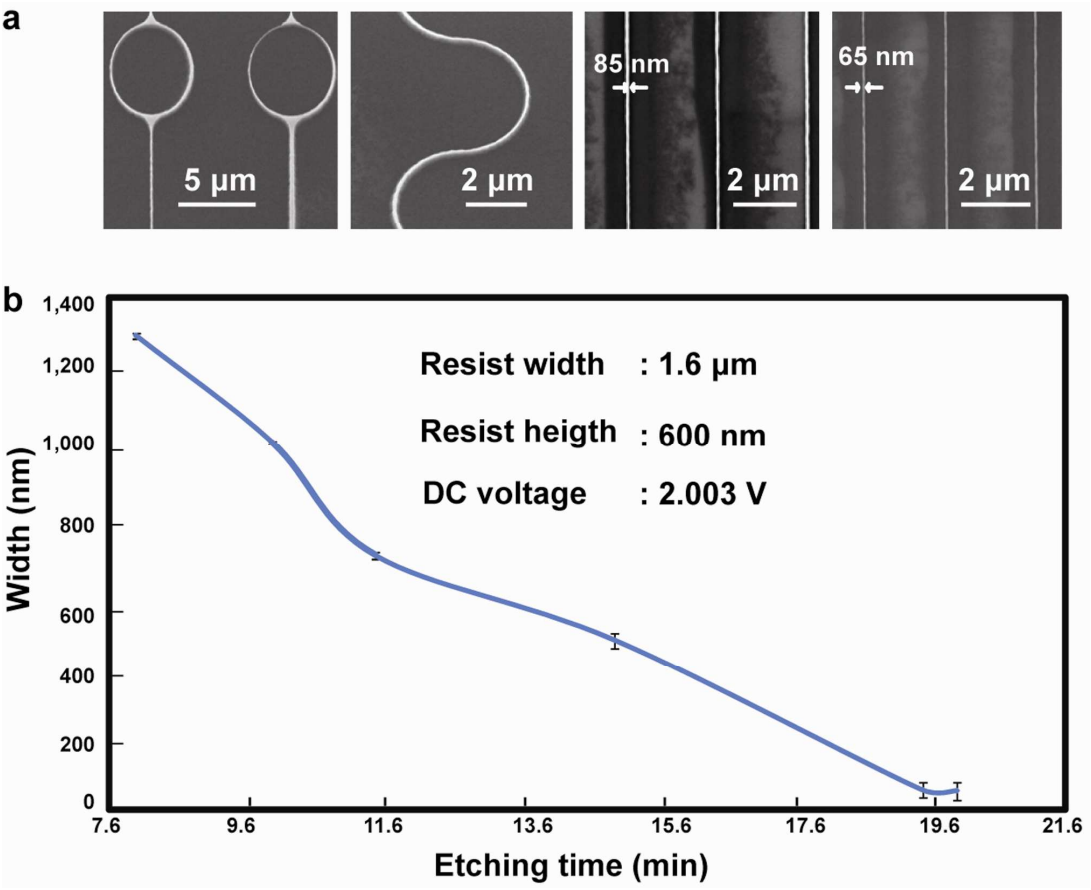

Figure S1. Nickel nanowire fabrication using PENCiL. a. Nickel nanowires with different widths and arbitrary shapes as determined by the photoresist mask and etching conditions. **b.** Calibration shows diameter dependence of nickel wires on etching time under a fixed applied DC voltage.

NiNW Width Statistics

1st etching, from 8 min to 19.5 min at 2.003 V DC, resist width: 1627 nm, Ni film thickness: 100 nm

# sample	etching time (mins)	width 1	width 2	width 3	width 4	width 5	width 6	width 7	width 8	average	standard deviation
1	8	1290	1339	1319	1321	1270.5	1220	N/A	N/A	1293.25	43.40478084
2	10	1000	1015	903	990	1015	1020	N/A	N/A	990.5	40.45058714
3	11.5	694.5	660	771	670	725	681	N/A	N/A	700.25	41.36876841
4	15.5	489.5	489.5	489.6	450.5	409	408.5	N/A	N/A	456.1	39.67089613
5	19.5	62.5	81	23.8	33.6	36	75	56	73	55.1125	21.54579425

2nd etching, from 8 min to 19.5 min at 2.003 V DC, resist width: 1627 nm, Ni film thickness: 100 nm

# sample	etching time (mins)	width 1	width 2	width 3	width 4	width 5	width 6	width 7	width 8	average	standard deviation
1	8	1300	1389	1403	1214	1311	1189	N/A	N/A	1301	87.5922371
2	10	1100	1110	1096	1123	997	1194	N/A	N/A	1103.333	63.28243569
3	11.5	703	784	713	659	690	654	N/A	N/A	700.5	47.17944468
4	15.5	401	474	471	501	447	530	N/A	N/A	470.6667	44.41921506
5	19.5	39	100	112	55.5	35.5	41	N/A	N/A	63.83333	33.58074845

*All widths are measured in nm

Figure S2. Nickel nanowire width statistics from PENCiL process. Statistics of Ni NW widths for different electrochemical etching times are given. A total of ten samples are listed above; two samples for each etch time. For all samples, the Ni wires were patterned at a 2 μm pitch. It should be noted that the deviations shown here are across large scale samples (3" wafers), where each numbered width column represents the NW width within some defined location (e.g., location 1 for width 1).

EDS and I-V plots of Ni structures created by PENCiL

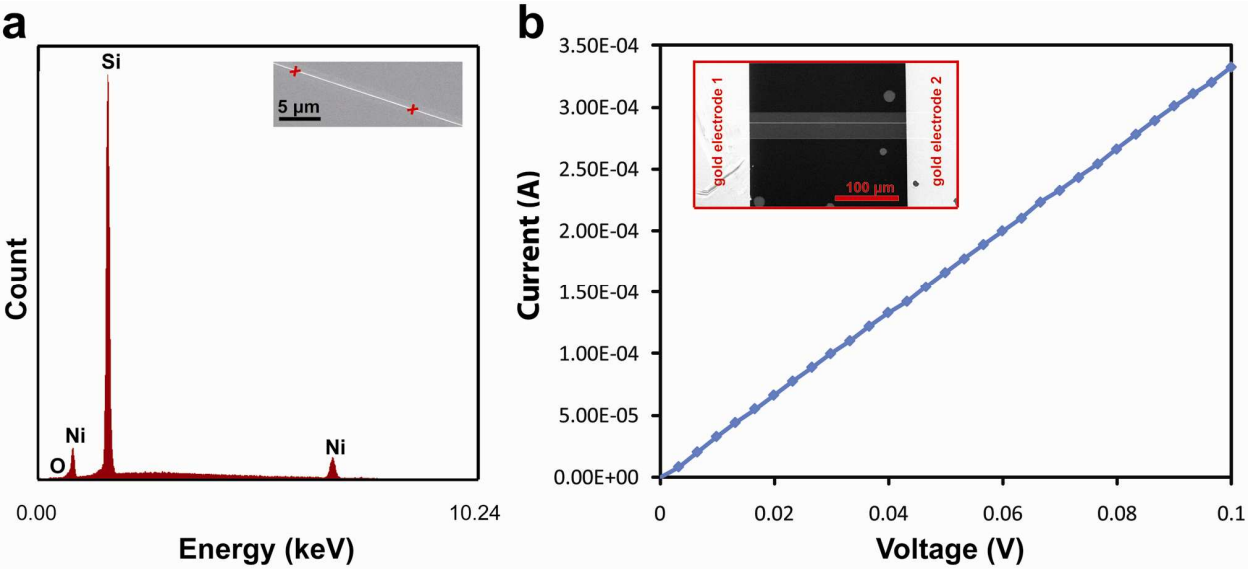

Figure S3. EDS and I-V plots of Ni structures created by PENCiL. a. EDS of NiNWs fabricated on Si shows no significant oxygen presence. Inset: NiNW showing EDS measurement points. **b.** I-V plot of a 100 nm thick, 200 µm long, 900 nm wide Ni wire fabricated by PENCiL, demonstrating an electrical resistivity of 135 Ω·nm (bulk Ni has a resistivity of 63 Ω·nm).[S1]

S1. 1974 Handbook of Physics and Chemistry 54th ed. (Cleveland, OH: CRC Press), p. F155.

PZT Nanowires Defined on a Pt/MgO Substrate

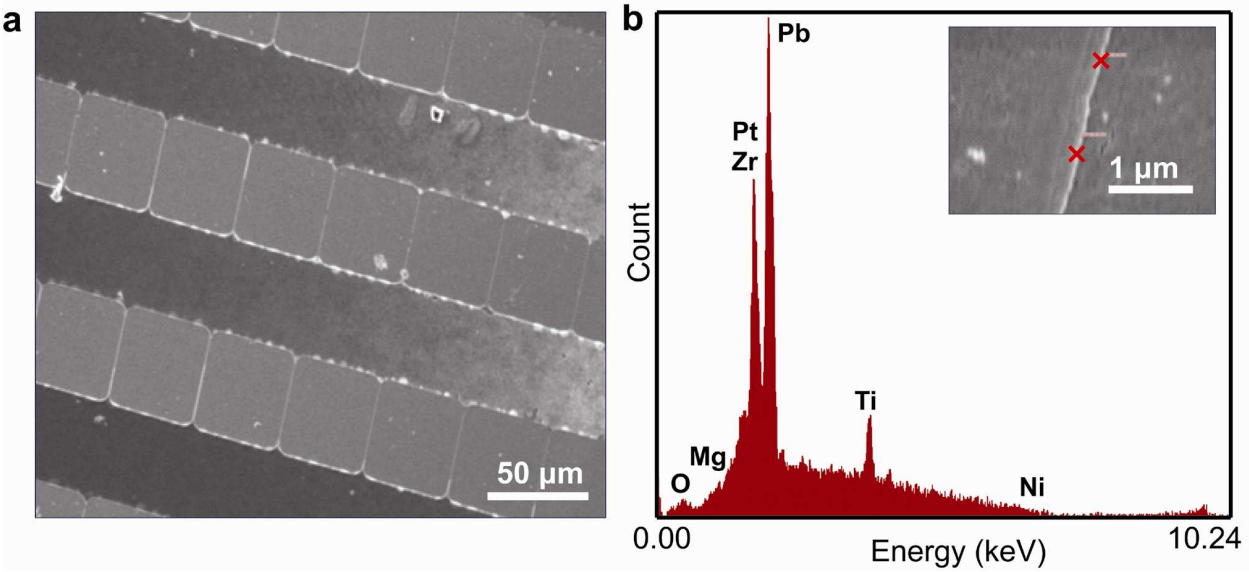

Figure S4. PZT nanowire array from a PZT film epitaxially grown on an MgO substrate. a. PZT nanowires (vertical) fabricated over a large area via PENCiL on Pt/MgO. **b.** EDS elemental analysis locally performed at points (red crosses) of a PZT NW (inset) which was fabricated on a Pt/MgO substrate. The O, Mg, Zr, Pt, Pb, Ti, and Ni peaks are labeled (Pt and Zr overlap).